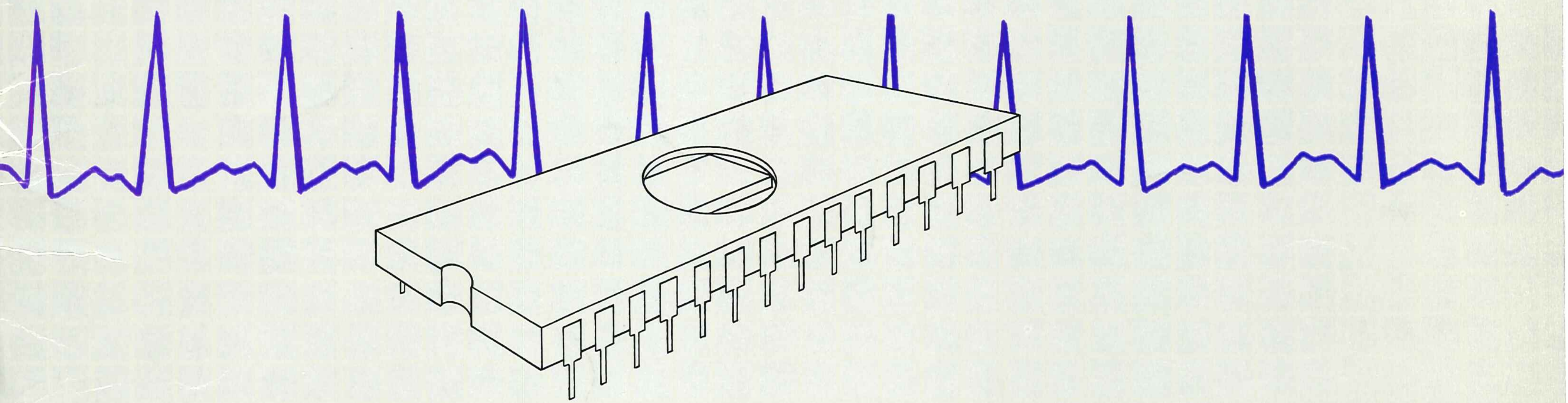
2920 Signal Processor: Breakthrough in Analog Design



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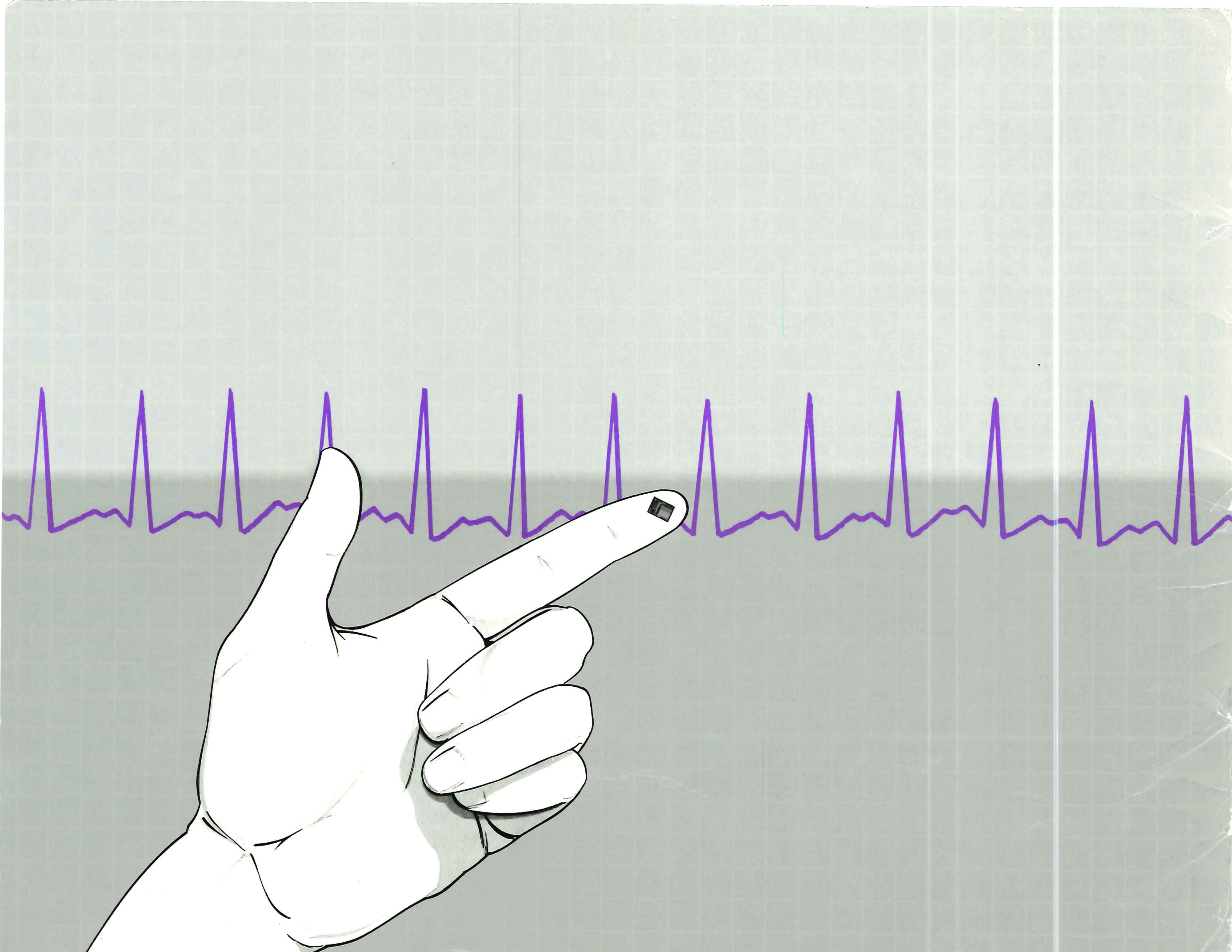


LSI Breakthrough for Analog Design

Large Scale Integration of electronic circuits is revolutionizing hundreds of industries, thousands of applications. For most companies, LSI meant the opportunity to change their competitive position, bringing to market dramatic improvements in product size, cost and manufacturing efficiency.

But the LSI revolution has also changed the rules for designers. LSI brought the pressure to develop systems with more features, at a faster pace, with lower cost and greater reliability.

To help streamline the designer's task, Intel introduced the first microcomputer in 1971. This intelligent LSI component made practical the concept of programmability and general purpose microelectronics. The microprocessor also made it possible for designers to use one component for a wide variety of digital applications, allowing the same set of building blocks to be arranged in an almost endless number of configurations. The effect has been to reduce cost and make LSI economical even for small volume applications. More importantly, the microcomputer freed the designer to create innovative solutions more rapidly and more efficiently.

Introducing the 2920 Signal Processor

Today, Intel brings the advantages of LSI to the analog world: our 2920 Signal Processor, the first general purpose analog system on a chip. Plus a complete computer-aided development package to help speed your systems to market faster than ever before.

The 2920 approach makes possible a true revolution in analog system design, bringing the power of programmability to analog designers.

Packing the equivalent of some 18,000 transistors on a single quarter-inch chip and operating hundreds of times faster than digital microcomputers, the 2920 allows you to implement real-time signal processing systems using a self contained, programmable processor.

The single-chip 2920 eliminates the need for costly components like precision resistors and capacitors. Circuit performance remains consistent from one production lot to another. And performance degradation over time due to circuit changes or noise is virtually eliminated.

For the first time, you can develop and implement analog designs using Intel's development system and support software. And the final design solution can literally be placed at your fingertips.

The advantages are obvious. Because of its size, the 2920 can fit into spaces too compact for analog systems on a board. Because it is programmable, you can use Intel's Development System hardware and software to significantly speed your product development and time-to-market. Finally, because the 2920 is a solid-state device produced with Intel's proven NMOS process, you're assured of reliability and manufacturing repeatability to a degree not possible with traditional analog designs.

Intel's 2920: A revolution in analog design

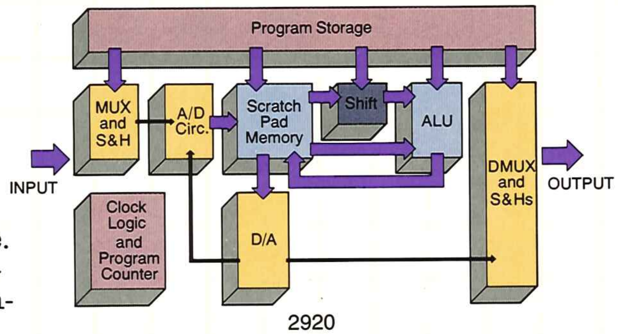
Because it is programmable, the 2920 Signal Processor can be used as a total-system-solution for literally thousands of different analog applications. The 2920 also opens up new applications, reducing what would be a board full of components to a single device.

In short, the single chip 2920 delivers the broad capability to implement single complex systems, such as modems, or several less complex circuits, such as filters and detectors. Other functions easily programmable with the 2920 include: limiters, rectifiers, multipliers, dividers, automatic gain controls and more.

How the 2920 works

Our 2920 is designed to operate as a single-chip, self-contained system. It embodies an architecture and instruction set developed especially for precision analog signal processing. It can perform all functions needed by a sampled data system. An on-board Erasable, Programmable Read Only Memory (EPROM) stores the program which controls all 2920 functions. This EPROM will store up to 192 instructions, each 24 bits long. These 24 bits are split into several fields, with each field controlling a subsystem of

the 2920. In order to maintain a constant sample rate, the program is executed sequentially, with no conditional branches. The sample rate is determined by the length of the program and the instruction cycle time—400 nsecs at the maximum 10-MHz clock rate. A full 192 instruction program, running at a 10-MHz clock rate will yield a 13-kHz sample rate. This allows processing of a signal bandwidth of approximately 4 kHz (maximum of 6.5 kHz with a rectangular filter). Shorter programs will have proportionately higher sample rates.



Device operations

Although many configurations are possible, operation of the 2920 can best be demonstrated by following an analog input signal through the Signal Processor subsystems until it appears at the output as a processed analog signal. Under program control, one of the four possible inputs is selected and the signal sampled and held. This signal is then converted to a digital word with up to 9 bits of linear conversion (sign bit and 8 amplitude bits). The bits formed by the successive approximation A/D conversion are stored in the Digital-Analog Register (DAR) until the conversion is complete. This register is the interface between the analog and the digital sections of the 2920 which operate simultaneously. The DAR's 9-bit word is then loaded into a scratch pad RAM location for further processing by the digital subsystems.

The digital subsystem shown in the block diagram includes the 2-port addressable RAM with forty 25-bit words, a binary shifter, and the 28-bit wide ALU. Under program control, two locations, A and B, are simultaneously addressed from the 40 possible RAM locations. The two 25-bit words are fetched with the data from the A address passing through a binary shifter. This shifter allows scaling from 2^2 (a 2-bit left shift) to 2^{-13} (a 13-bit right shift). These values are then propagated to the ALU for processing with digital instructions specified by the program. The 25-bit result of that operation is loaded into the B address location of the RAM. When outputting a value, the nine most significant bits of a RAM location are loaded into the DAR. The DAR drives the D/A converter, whose output can be routed to any of eight analog outputs by the output demultiplexer and S&Hs.

What makes the 2920 fast enough for real-time processing is that the analog operation, dual memory fetch, binary shift, ALU execution, and write back to RAM all take place in as little as 400 nsecs (depending on the clock rate of up to 10 MHz).

A fresh approach to analog circuit design

Despite its revolutionary implications, the 2920 does not replace any of the traditional functions of the analog designer. Instead, the 2920 and its development package increase design efficiency...while giving new options for design implementation.

Programming the 2920 to implement a particular system is done by first developing a system block diagram. Each block is then realized with assembly language routines, then assembled and simulated with the 2920 development support package. Instead of complex interfaces between subsystems, the 2920 lets you easily form blocks into the total system through software.

The end result is that manufacturers can offer customers a wider range of products with reduced cost, size and weight. And that designers can implement these new designs far more quickly than previous approaches.

Introducing the first general purpose analog processor

Designers can implement virtually any analog system in the DC to 10-kHz range with the programmable 2920 Signal Processor and its complete hardware and software development package. Applications are as broad as your imagination.

Use the 2920 as an economical alternative to developing custom analog circuits without the risks and commitments associated with special purpose components. It means unprecedented design flexibility, allowing you to make modifications, design improvements and add extra features by simply changing the 2920 program.

For example, the 2920 is an ideal single chip system solution for applications like modems and scanning spectrum analyzers. Or to implement DTMF receivers, phase lock loops, complex filters, linearizers, waveform generators, guidance and control modules, test and instrumentation circuits, speech processors, seismic processors, and medical instrumentation. Here are a few sample configurations:

Building a Single Chip Modem

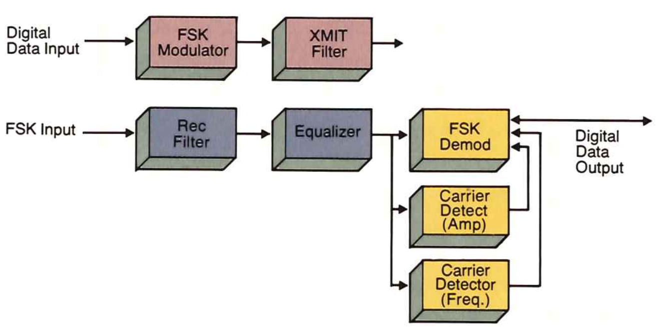
The 2920's 192 instructions are enough to implement a 1200 bit-per-second frequency shift keyed (FSK) modem—complete with an FSK modulator, receive filters, selectable equalizer, FSK demodulator, amplitude and frequency carrier detection and strap options on a single IC (see block diagram). Higher speed modems using phase shift keyed (PSK) signaling can also use the 2920 to implement PSK modulators/demodulators and filters. You can even build adaptive equalizers by cascading 2920s with about 10 coefficients per device.

Audio Scanning Spectrum Analyzer

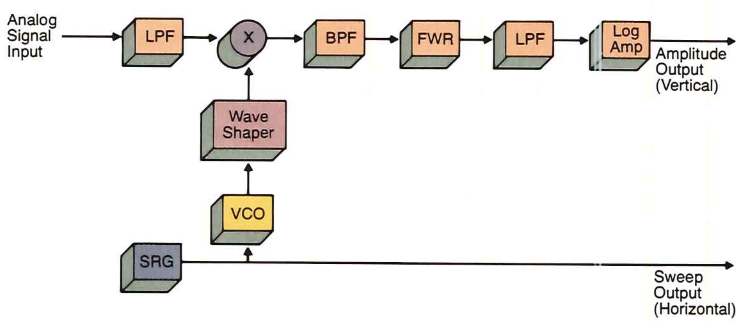
A single 2920 is sufficient to implement an audio scanning spectrum analyzer (see block diagram). This analyzer is complete with an input filter, sweeping local oscillator, mixer, bandpass filter, envelope detector, and a precision logarithmic output amplifier. The 2920 implementation makes a straightforward design task of high stability and very high frequency resolution spectral analysis...yet uses only 75% of the EPROM storage.

Multi-Frequency Receiver/Analyzer

An example of the typical filter circuit possible with Intel's 2920 has the input signal bandlimited, amplitude normalized and then analyzed by a bank of bandpass filters (see block diagram). Filter outputs can be envelope detected and then buffered or compared to a threshold. In this example, the eight outputs are selected to be TTL compatible,



Single Chip Modem



Audio Scanning Spectrum Analyzer

providing a digital interface. Analog outputs can also be made available using the output mode control pins.

Digital Filters made easy

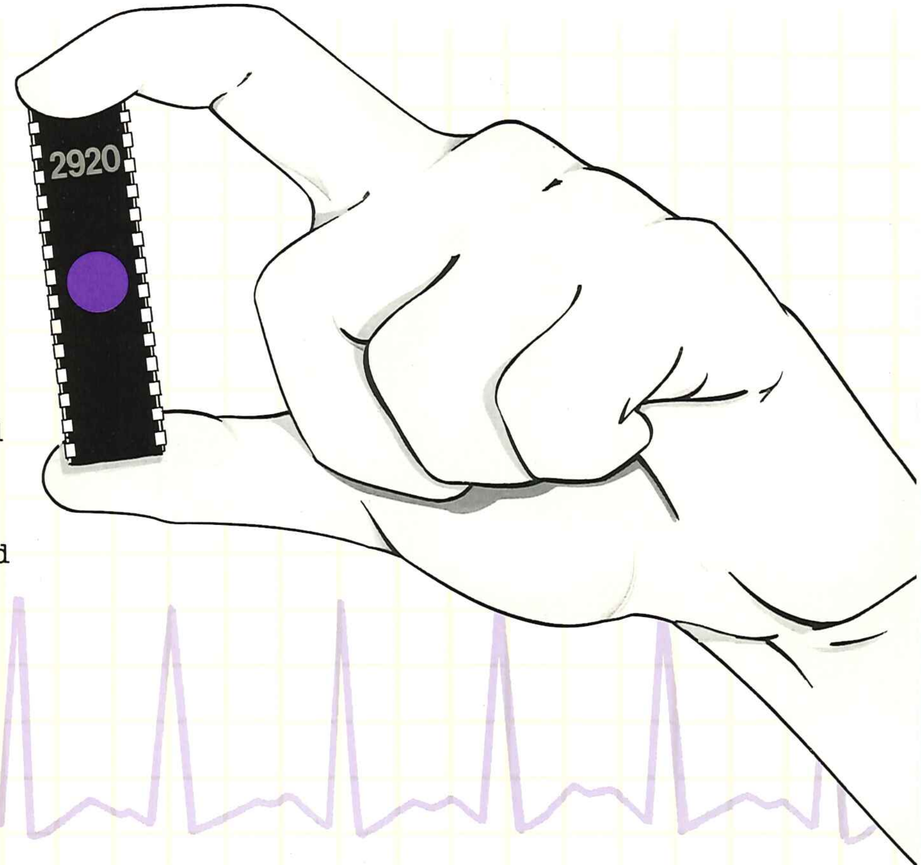
Use the 2920 to implement digital filters in almost any configuration and with very high complexity. The block diagram shows one example: a three-pole, two-zero, lowpass filter.

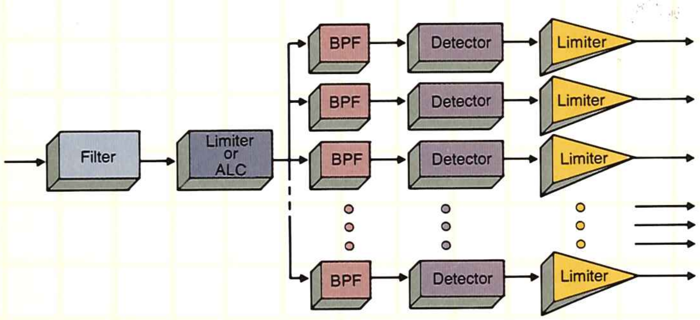
Several filters can be implemented, using up to a maximum of 40 delay elements with coefficients that require up to 192 instructions for implementation. A typical filter uses approximately 8-10 instructions per quadratic section (a complex pole or zero pair).

Typical uses for the 2920 in this kind of application include lowpass filters, bandpass filters, phase equalizers, and arbitrary transfer functions.

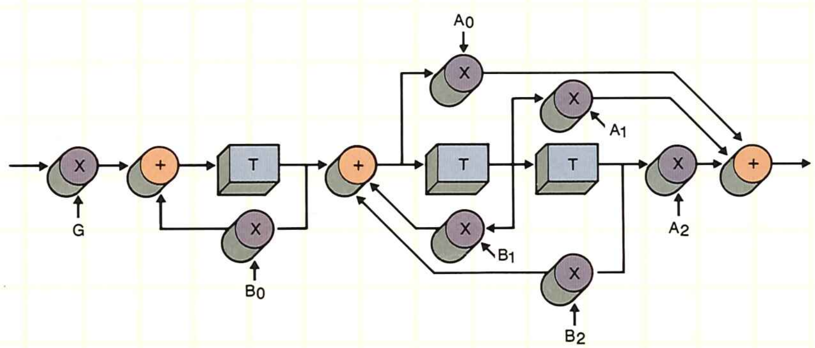
Digital Input/Output

Since the 2920's A/D conversion is under program control, a single bit of conversion can be implemented to read a logical level at one of the four analog inputs. Here, the converted amplitude bit takes on the same logical value as the input, which could then be used as data or as a control input by the Arithmetic Logic Unit (ALU). Serial digital bit streams can also be outputted by use of mode control pins, which convert the output pins to TTL compatible. Simple shift instructions and logical operations internal to the 2920 are used to perform the serial data movement at both input and output. The serial I/O of a 9-bit digital word requires approximately 25 instructions.

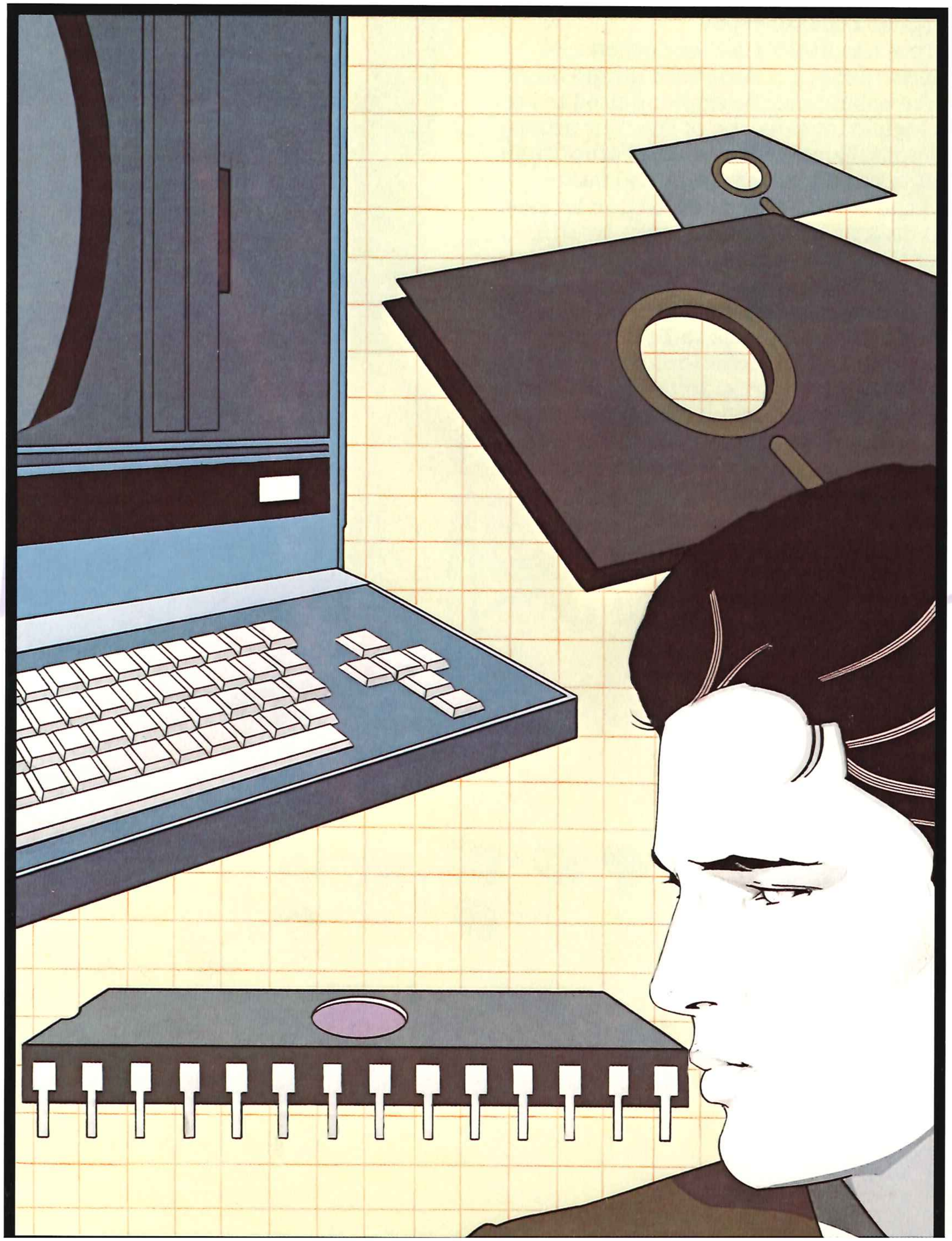




Multi-Frequency Receiver/Analyzer



Digital Filter



Intel delivers the development support to speed system implementation.

For simplicity in developing the 2920 system, Intel supplies an advanced design package of both hardware and software. Using these design tools, the typical design sequence for the 2920 is straightforward.

Our Intellec® Microcomputer Development System with SP20 Support Package furnishes the designer with a 2920 assembler, software simulator and EPROM programmer.

The diskette-based Intellec system is the key to the 2920's improved design efficiency. With this system, the designer can enter, review and edit with Intellec's keyboard and CRT. Intellec's accompanying operating software, called ISIS, provides the system utilities necessary for program development. The 2920's assembler and simulator are also diskette based, and run under ISIS' operating system software.

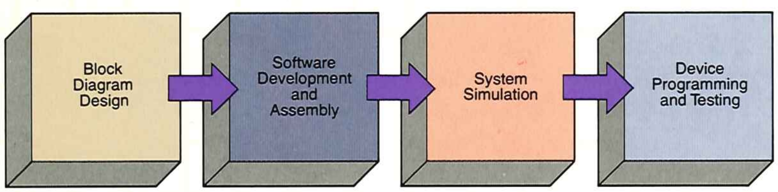
Typical development sequence

In the first step, you develop a detailed block diagram similar to those used for standard continuous analog designs.

Each of the function blocks is converted into 2920 code and arranged in proper sequence. With the Intellec Microcomputer Development System, each block can be assembled and simulated, either individually or as a system... depending on their complexity.

Intel's 2920 assembler translates user-written symbolic assembly language programs into machine code. This assembler generates several outputs, including comments, error/warning diagnostics, the number of RAM and ROM locations used, and a table of user-defined symbols. Ultimately, the machine code is used as an input to the software simulator, and to the EPROM programmer.

In the second step, you use the simulator to test the actual operation of the new program. Operating entirely in software, the 2920 simulator allows you to test and debug 2920 programs without building a breadboard. Initial testing is accomplished by specifying input signals and simulating program execution.



The 2920 Development Sequence

Test, change, trace... effortlessly

If a problem occurs, the simulator's debug tools can be called into action, ready to test variables at different points in the circuit. Just use the simulator to stop or trace action at any point, and display registers and memory locations inside the 2920. Implement program changes, when necessary, with the simulator by directly changing the contents of the 2920 through the Intellec system keyboard. Then retest the revised program. That's how simple it is to test, change, trace or manipulate virtually every parameter of the 2920 as part of the debug procedure. You can document each step by using a line printer to generate hard copy. Or simply store your program on disk for later analysis.

Once your system is complete in software, you can quickly transfer the program to the 2920 Signal Processor via our Intellec system and Universal PROM Programmer. With your simulated program operating to specifications, you can load it into the 2920 chip for real-time testing.

How the 2920 total system approach gives you the competitive edge

With the 2920, it becomes evident how the advantage of digital processing in an analog environment can give you the edge. Since each production system will identically duplicate the original 2920 prototype without tweaking or tuning, you can convert the prototype into a production product. Forget drifting, aging, temperature effects or other typical problems that plague analog system production and reliability. You develop a digital code, so your system will be precisely duplicated in manufacturing.

All told, you've got the edge on a shorter development cycle. The edge on a new technology and vast new product opportunities. The edge it takes to speed your systems to market well ahead of the competition. The edge with a breakthrough in analog design... Intel's 2920 Signal Processor, Intel's SP20 Support Package, and the Intellec® Microcomputer Development System. They're all here today.

Intel's new 2920 product support

Everything you need to begin designing a new generation of real-time analog processing systems is available now.

The 2920 Family of single-chip analog signal processors offers a variety of speed versions for different applications.

The SP20 Support Package, including assembler, simulator, and the EPROM Programming Personality Card.

Intel's Intellec® Development System provides a keyboard, CRT, diskette based operating system, 64K RAM, and Universal PROM Programmer.

2920 Signal Processing Workshops
A typical workshop will cover such topics as:

- Sampled Data Systems and Digital Signal Processing
- 2920 Signal Processor Architecture
- Use of 2920 Assembly Language
- Operation of Intellec® Development Systems
- Operation of 2920 Assembler and Simulator
- Applications Design Labs

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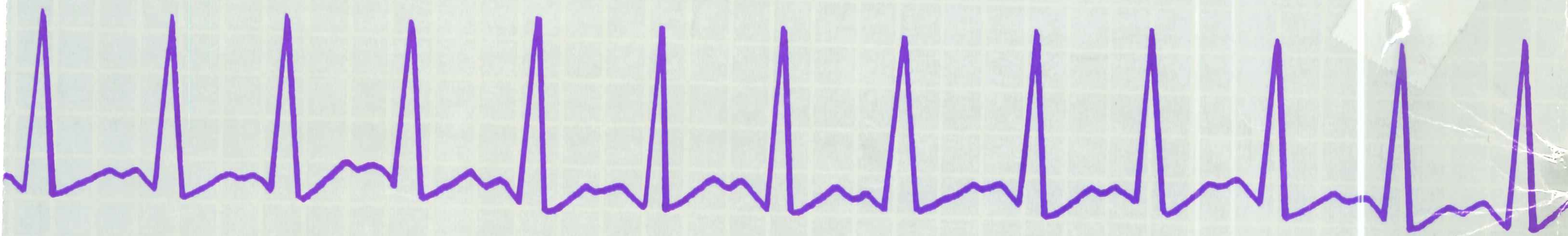

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